

COMPUTER  
TECHNOLOGY

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1620 GENERAL PROGRAM LIBRARY

Evaluation of a Determinant

5.0.019

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1620 USERS GROUP PROGRAM REVIEW AND EVALUATION

(fill out in typewriter or pencil, do not use ink)

Program No. \_\_\_\_\_

Date \_\_\_\_\_

Program Name: \_\_\_\_\_

1. Does the abstract adequately describe what the program is and what it does? Yes \_\_\_ No \_\_\_

Comment \_\_\_\_\_

2. Does the program do what the abstract says? Yes \_\_\_ No \_\_\_

Comment \_\_\_\_\_

3. Is the Description clear, understandable, and adequate? Yes \_\_\_ No \_\_\_

Comment \_\_\_\_\_

4. Are the Operating Instructions understandable and in sufficient detail? Yes \_\_\_ No \_\_\_

Comment \_\_\_\_\_

Are the Sense Switch options adequately described (if applicable)? Yes \_\_\_ No \_\_\_

Are the mnemonic labels identified or sufficiently understandable? Yes \_\_\_ No \_\_\_

Comment \_\_\_\_\_

5. Does the source program compile satisfactorily (if applicable)? Yes \_\_\_ No \_\_\_

Comment \_\_\_\_\_

6. Does the object program run satisfactorily? Yes \_\_\_ No \_\_\_

Comment \_\_\_\_\_

7. Number of test cases run \_\_\_\_\_. Are any restrictions as to data, size, range, etc. covered adequately in description? Yes \_\_\_ No \_\_\_

Comment \_\_\_\_\_

8. Does the Program Meet the minimal standards of the 1620 Users Group? Yes \_\_\_ No \_\_\_

Comment \_\_\_\_\_

9. Were all necessary parts of the program received? Yes \_\_\_ No \_\_\_

Comment \_\_\_\_\_

10. Please list on the back any suggestions to improve the usefulness of the program. These will be passed onto the author for his consideration.

Please return to:

Your Name \_\_\_\_\_

Mr. Richard L. Pratt  
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7500 Old Xenia Pike  
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Company \_\_\_\_\_

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User Group Code \_\_\_\_\_

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EVALUATION

OF A

D E T E R M I N A N T

by

Reginald T. Harling  
Associate Professor of Mathematics

AIR FORCE INSTITUTE OF TECHNOLOGY  
Wright-Patterson AFB, Ohio

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Modifications or revisions to this program, as they occur,  
will be announced in the appropriate Catalog of Programs  
for IBM Data Processing Systems. When such an announce-  
ment occurs, users should order a complete new program  
from the Program Information Department.

DECK KEY

1. Determinant Source Deck
2. Determinant Object Deck

AFIT 20  
November, 1962

EVALUATION OF A DETERMINANT

R. T. Harling  
Programmer

ABSTRACT

TITLE: Evaluation of a Determinant

SUBJECT CLASSIFICATION: 5.0

AUTHOR; ORGANIZATION: Reginald T. Harling, Air Force Institute of Technology, Wright-Patterson, AFB, Ohio

DIRECT INQUIRIES TO:

NAME: Reginald T. Harling - Address: Math Department, AFIT, Wright-Patterson, AFB, Ohio

PHONE: CL3-7111, Extension 29115

PURPOSE: This program will evaluate a determinant of order 40 or less.

METHOD: The method used is that of Chio, and is described in Kunz, "Numerical Analysis," McGraw-Hill, 1957, Chap 10.

RESTRICTIONS, RANGE: Round-off error decrease the accuracy of the answer as the order of the determinant increases.

STORAGE REQUIREMENTS: 20K

EQUIPMENT SPECIFICATIONS: IBM 1620, with 20,000 digits of memory, card input-output. No additional features are needed.

ADDITIONAL REMARKS: The source program was written in SPS language, having macro-ops for the input and output conversion of floating point numbers. The present program differs from 5.0.005 principally in that, in the present program, all conversions of numbers, between external and internal forms, are done by the machine.

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Purpose: This program will evaluate a determinant of order 40 or less.

Equipment Needed: IBM 1620, 20,000 digits of memory, and input-output. No additional features are needed.

Method: The method used is that of Chio, and is fully described in Kunz, "Numerical Analysis." McGraw-Hill, 1957, Chapter 10. Briefly, the procedure is as follows:

a) Each element of the top row of the determinant is divided by its first element,  $A_{11}$ , so that the new  $A_{11}$  is unity. (In case  $A_{11} = 0$ , two columns are interchanged to make  $A_{11}$  non-zero.)

b) A new array is formed by the rule

$$A_{ij} \xrightarrow{A_{11}} * A_{ij} \rightarrow A_{ij}$$

c) Column 1 and row 1 are removed from the array. What remains is a determinant of order one less than the original.

d) The reduction in order is repeated until a determinant of order two can be evaluated by cross multiplication.

e) If, at any stage, the top row of the determinant should contain only zero elements, the value of the determinant is at once reported as being zero. This situation can be recognized by the fact that the word ZERO, rather than a numeric representation, is typed.

Program Language: The program was written in SPS language, having macro-ops for the input and output conversion of floating point numbers.

Data Input: The first data card must carry  $N$ , the order of the determinant, as a two-digit fixed point number (e.g., 03, 09, 25, etc) in card columns 1 and 2.

The second, third, etc., data cards must carry the elements of the determinant, commencing with those of row 1, and continuing to lower rows. These numbers must be in any external floating point form acceptable to the INC routine. They may be presented one per card, or any number per card, the numbers being separated by one or more blanks or commas. It is not necessary to follow the last number on a card by a record mark. If more than  $N^2$  elements are presented, only the first  $N^2$  of them will be read.

Operation:

1. Set the overflow switch to PROGRAM, others to STOP.
2. Put the SPS object deck of this program into the read hopper and press LOAD. Press READER START to read in the last two cards.

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3. Place the data cards in the read hopper and press START and READER START. It will again be necessary to press READER START to read in the last two cards.

4. The machine will evaluate the determinant and type out

"DETERMINANT IS -----"

followed by its value.

5. The program may then be restarted by placing new data cards in the read hopper and returning to 3 above.

6. To recommence the program before it has printed an answer press in turn,

INST. STOP, RESET, INSERT, RELEASE, START,

and return to 3 above.

Comments: A tenth order determinant is evaluated in about 20 seconds. A thirtieth order determinant requires 12 minutes. Round-off error decreases the accuracy as the order increases. A determinant of order 30 was computed with an accuracy of five significant figures.

\* EVALUATION OF A DETERMINANT

START	TDM	401,1	00402	15	00401	00001
	TF	FACT,ONE	00414	26	02279	02269
	TF	FACT-2,ONE-2	00426	26	02277	02267
	RNCD	N-1	00438	36	02280	00500
	SF	N-1	00450	32	02280	00000
	M	N,N	00462	23	02281	02281
	SF	97	00474	32	00097	00000
	TF	NSQ,99	00486	26	18444	00099
	TFM	CNT,0,9	00498	16	18447	00000
	TFM	ABC+23,ARRAY	00510	16	00641	02451
CAB	RACD	AREA	00522	37	02283	00500
	TFM	PQ+11,AREA+157	00534	16	00557	02440
PQ	BD	PQ2,	00546	43	00582	00000
	SM	PQ+11,2,10	00558	12	00557	00002
	B	PQ	00570	49	00546	00000
PQ2	TF	PQ1+6,PQ+11	00582	26	00612	00557
	AM	PQ1+6,3,10	00594	11	00612	00003
PQ1	TFM		00606	16	00000	00000
	DC	2,@,*	00617		00002	
ABC	INC	,AREA	00618	16	18657	00641
	AM	ABC+23,10,10	00630	49	18606	00000
	AM	CNT,1,10	00637	00005	00000	
	C	NSQ,CNT	00642	00005	02283	
	BE	AAB	00648	11	00641	00010
	BNR	ABC,AREA	00660	11	18447	00001
	B	CAB	00672	24	18444	18447
AAB	MM	N,10,10	00684	46	00720	01200
	SF	97	00696	45	00618	02283
	TF	TN,99	00708	49	00522	00000
	TF	CNT,N	00720	13	02281	00010
	SM	CNT,2,10	00732	32	00097	00000
	BP	TUFF	00744	26	18492	00099
	BZ	EASY	00756	26	18447	02281
PRINT	RCTY		00768	12	18447	00002
	WATY	MESS1	00780	46	01030	01100
	ØUTC	AREA,ARRAY,01608	00792	46	00898	01200
			00804	34	00000	00102
			00816	39	18449	00100
			00828	16	18657	00851
			00840	49	18626	00000
			00847	00005	02283	
			00852	00005	02451	
			00857	00005	01608	

	WATY AREA	00862 39 02283 00100		01348 49 18586 00000
	H	00874 48 00000 00000		01355 00005 00000
EASY	B START+12 FM ARRAY,ARRAY+30	00886 49 00414 00000 00898 16 18657 00921 00910 49 18546 00000 00917 00005 02451 00922 00005 02481	B26 TFLS ,TEMP	01360 00005 00000 01366 16 18657 01389 01378 49 18586 00000 01385 00005 00000 01390 00005 T8502
	FM ARRAY+10,ARRAY+20	00928 16 18657 00951 00940 49 18546 00000 00947 00005 02461 00952 00005 02471	C CNT,N BE B27 AM CNT,1,10 A B24+28,TN A B25+23,TN A B25+28,TN A B26+23,TN B B24	01396 24 18447 02281 01408 46 01492 01200 01420 11 18447 00001 01432 21 01334 18492 01444 21 01359 18492 01456 21 01364 18492 01468 21 01389 18492 01480 49 01306 00000 01492 16 18657 01515 01504 49 18546 00000 01511 00005 02279 01516 00005 18512
	FS ARRAY,ARRAY+10	00958 16 18657 00981 00970 49 18526 00000 00977 00005 02451 00982 00005 02461	B27 FM FACT,M0NE	01522 16 18657 01545 01534 49 18546 00000 01541 00005 02279 01546 00005 02451 01552 26 18522 02451 01564 26 18520 02449 01576 16 01623 02451 01588 16 18447 00000 01600 16 18657 01623 01612 49 18566 00000 01619 00005 00000 01624 00005 T8522
TUFF	B PRINT TFM BBB+11,ARRAY-9	01018 49 00804 00000 01030 16 01065 02442 01042 16 18447 00001	A23 FM FACT,ARRAY	01553 49 18546 00000 01554 00005 02279 01556 26 18522 02451 01564 26 18520 02449 01576 16 01623 02451 01588 16 18447 00000 01600 16 18657 01623 01612 49 18566 00000 01619 00005 00000 01624 00005 T8522
BBB	BD NZ, C CNT,N BE PRIN AM CNT,1,10 AM BBB+11,10,10	01054 43 01186 00000 01066 24 18447 02281 01078 46 01126 01200 01090 11 18447 00001 01102 11 01065 00010 01114 49 01054 00000	TF CØN,ARRAY TF CØN-2,ARRAY-2 TFM A3+23,ARRAY TFM CNT,0,10 FD ,CØN	01630 11 18447 00001 01642 11 01623 00010 01654 24 18447 02281 01666 47 01600 01300 01678 16 18524 00001 01690 16 01832 02461 01702 16 01802 02451 01714 21 01802 18492 01726 16 01887 02451 01738 21 01887 18492 01750 11 01887 00010 01762 16 18447 00001 01774 16 18657 01797 01786 49 18586 00000 01793 00005 02293 01798 00005 00000
PRIN	RCTY WATY MESS1 WATY MESS2	01126 34 00000 00102 01138 39 18449 00100 01150 39 18479 00100 01162 48 00000 00000	A3	01804 16 18657 01827 01816 49 18586 00000
NZ	H B START+12 SM CNT,1,10	01174 49 00414 00000 01186 12 18447 00001	AM CNT,1,10 AM A3+23,10,10 C CNT,N	
A22	BZ A23 TFM B24+28,ARRAY TFM B25+23,ARRAY TFM B25+28,ARRAY TFM B26+23,ARRAY	01198 46 01522 01200 01210 16 01334 02451 01222 16 01359 02451 01234 16 01364 02451 01246 16 01389 02451	BL A3 TFM 1,1,10 TFM B29+28,ARRAY+10 TFM B28+28,ARRAY	
	MM CNT,10,10 A B25+28,99 A B26+23,99	01258 13 18447 00001 01270 21 01364 00099 01282 21 01389 00099	A B28+28,TN TFM B30+23,ARRAY A B30+23,TN	
B24	TFM CNT,1,10 TFLS TEMP,	01294 16 18447 00001 01306 16 18657 01329 01318 49 18586 00000 01325 00005 T8502 01330 00005 00000	AM B30+23,10,10 TFM CNT,1,10 TFLS AREA+10,	
B25	TFLS ,	01336 16 18657 01359	B28 TFLS CØN,	

<p>FM CØN, AREA+10</p> <p>B30 FS ,CØN</p> <p>AM B29+28,10,10 AM B30+23,10,10 AM CNT,1,10 C CNT,N BL B28 A B28+28,TN TFM B29+28,ARRAY+10 AM B30+23,10,10 AM I,1,10 C I,N BL B28-12 TFM I,1,10 TFM B31+23,ARRAY TFM B31+28,ARRAY A B31+28,TN AM B31+28,10,10 TFM CNT,1,10 B31 TFLS ,</p> <p>AM B31+23,10,10 AM B31+28,10,10 AM CNT,1,10 C CNT,N BL B31 AM B31+28,10,10 AM I,1,10 C I,N BL B31-12 SM N,1,10 B AAB DC 8,10000000 ØNE DC 2,01 FACT DS 10 N DS 2 AREA DAS 80 ARRAY DSB 10,1600 NSQ DS 3</p>	<p>01823 00005 T8522 01828 00005 Ø0000 01834 16 18657 01857 01846 49 18546 00000 01853 00005 T8522 01858 00005 Ø2293 01864 16 18657 01887 01876 49 18526 00000 01883 00005 00000 01888 00005 T8522 01894 11 01832 000T0 01906 11 01887 000T0 01918 11 18447 00001 01930 24 18447 02281 01942 47 01774 01300 01954 21 01802 18492 01966 16 01832 Ø2461 01978 11 01887 000T0 01990 11 18524 00001 02002 24 18524 02281 02014 47 01762 01300 02026 16 18524 00001 02038 16 02121 Ø2451 02050 16 02126 Ø2451 02062 21 02126 18492 02074 11 02126 000T0 02086 16 18447 00001 02098 16 18657 Ø2121 02110 49 18586 00000 02117 00005 Ø0000 02122 00005 Ø0000 02128 11 02121 000T0 02140 11 02126 000T0 02152 11 18447 00001 02164 24 18447 02281 02176 47 02098 01300 02188 11 02126 000T0 02200 11 18524 00001 02212 24 18524 02281 02224 47 02086 01300 02236 12 02281 00001 02248 49 00720 00000 02267 00008 02269 00002 02279 00010 02281 00002 02283 00080 02451 00010 01600 18444 00003</p> <p>CNT DS 3 MESS1 DAC 15, DETERMINANT IS@ MESS2 DAC 6, ZERØ@ TN DS 3 TEMP DS 10 DC 8,-10000000 MØNE DC 2,01 CØN DS 10 I DS 2 DEND START</p>	<p>18447 00003 18449 00015 18479 00006 18492 00003 18502 00010 18510 00008 18512 00002 18522 00010 18524 00002 00402</p>
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LOAD SUBROUTINES